# PLURIMODULE GIS FOR PUBLIC WORKS: THE MALTESE FORTIFICATION CASE STUDY

# GIS PLURIMODULAR PARA OBRAS PÚBLICAS: O ESTUDO DE CASO DA FORTIFICAÇÃO DE MALTA

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## ABSTRACT

This paper presents a preliminary version of a GIS platform oriented towards the building restoration and regeneration processes of the historical and architectural heritage protection of the Republic of Malta. This tool has been designed on behalf of the Public Work Division of the Maltese Government. It is based on the assumption that a regeneration action requires different information levels: i.e. analysis of the study area, survey of the facilities to be regenerated, historical and typological analysis of the works involved in the remedial action, deterioration analysis, regeneration project. This whole set of information is indispensable if a philological approach is to be adopted as a methodological basis.

**Keywords**: GIS; Restoration; Regeneration; Maltese architectural heritage.

## RESUMO

Este trabalho apresenta uma versão preliminar de uma plataforma de GIS orientada para os processo de restauração e recuperação de edificações da proteção da herança histórica e arquitetônica da República de Malta. O plano foi concebido em nome da Divisão de Obras Públicas do Governo de Malta. Baseia-se no princípio de que uma ação recuperadora requer níveis diferentes de informações, ou seja, uma análise da área em estudo, um levantamento das facilidades a serem recuperadas, uma análise histórica e tipológica das obras envolvidas na ação de recuperação, uma análise da deterioração, e um projeto de recuperação. Todo esse conjunto de informações é indispensável de uma abordagem filosófica for adotada como base metodológica.

**Palavras-chave:** GIS; Restauração; Recuperação; Herança arquitetônica de Malta.

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This paper describes a preliminary testing of a Geographical Information System designed for the functional regeneration and restoration of the Maltese architectural heritage.

The main feature of this system is not so much the detailed scale which is provided (although not negligible from a technical viewpoint), but rather the management of all the information required to follow the proper philological approach of the actions relevant for the regeneration project.

Data included in the Information System do not simply provide a comprehensive and accurate description of the territory. The cognitive needs linked to the development of regeneration and improvement actions for the Fortifications system led us to shift from a geographical representation scale to a representation of the architectural and detail scale. Yet, at this scale, only a part of the information – because of its intrinsic nature – lends itself to be managed by means of alphanumerical databases.

The Public Work Division information requirements and the regeneration design of the Fortifications and of their individual architectural elements have pointed out the *multimedia* solution as the best option available.

What makes the project more complicated than an ordinary Geographical Information System is the fact that it is not possible, except to a limited extent, to resort to the normal query procedures based on the Boolean criteria (which are built in an SQL language-based query motor). This entails the need to reorganise information according to the logical-formal pattern adopted by experts in the field, with a view to guarantee access to information according to the different requirements relevant to the complex regeneration project.

The best solution identified to this problem is to exploit the potentials provided by a browser environment, which, if properly interfaced with the GIS platform, is able to integrate different otherwise incompatible applications. In other words, the need to manage information leads to a series of logical sequences provided by an HTML protocol-based hypertextual links structure, in order to give an effective answer to the problems relevant to the cognitive analysis processes.

Therefore, the objects that were already defined at territorial scale (both in terms of meaning and of information contents expressed by means of alphanumerical databases) were provided with hypertextual links, to guarantee access to the information set, including graphical representations, images and files.

From a technical point of view, test results concerning the system performance have been satisfactory. Yet, guided surfing itineraries through the different information environments still require further improvement.

This problem will not be easily solved, since the tool which is being developed is highly technical. It should be able to reproduce the mental processes of a scientific researcher or of an expert in the field to guarantee access to the information specifically required.

Hence, future efforts will be mainly devoted to the improvement of surfing procedures (in addition to information update and to the implementation of new applications). Only an additional experience with this new tool will allow a more refined tuning of the logical model underlying the whole system.

To conclude, it should be noted that, given the way it has been conceived, the M.G.I.S. offers an *open communication structure*. In other words, the system contents and the potential applications can be further updated thanks to information exchange with other Geographical Information Systems implemented on the Maltese territory, if any.

## PLANNING PROCEDURE: FROM ANALYTICAL COGNITIVE PROCESSES TO TECHNOLOGICAL SYNTHESIS

The whole project is divided into different phases of a scientific and political nature (G. Spegnesi, 1979) that require co-ordination, thus achieving a synthesis which provides a decision-making basis.

The entire process is based on analyses aimed at the *knowledge*, both of the physical and environmental structure, which is the object of our action. This knowledge is achieved through cognitive processes based on historical and typological analyses, architectural surveys, analyses regarding the spatial lay-out and urban policies in action.

Once the description of both the artefact and the environmental context surrounding it has been provided, it is possible, on the one hand, to develop urban policy proposals (aimed at reviewing those in action, but also at rewriting them, if necessary), and, on the other hand, to carry out the executive restoration and functional recovery of each artefact. This consideration is based on the assumption that all this might be possible without undermining or distorting their content as well as their historical and aesthetic meanings, which would otherwise deprive them of their natural identity. The final phase includes a technical and political-administrative evaluation concerning the feasibility of the integrated regeneration project. It now seems clear that, from a strategic viewpoint, it is precisely this last phase that plays a fundamental role, as it is mainly in this context that decisions are made. It is therefore critical to guarantee the completeness of the information which serves as a decision support basis. However, at the same time, it is also necessary to ensure the utmost transparency of the entire project process, in order to reach overall consensus. The whole course can undoubtedly be "engineered" by resorting to advanced technologies which, besides facilitating the integration of the communication protocols by providing valid support to the analytical and project phases, also offer the great advantage of proposing themselves as synthesis tools of the various cultural and political stages, which converge in a regeneration project. This constitutes in itself a highly respectable support to decisions and, given the intrinsic nature of the advanced technologies, is a means of communication, thus allowing total transparency of the process and favouring its possible success in terms of public consensus.

The use of Information Technology (IT) as a problem-solving support in relation to land-use actions is by now common practice, thanks to the development of tools able to process various types of graphic and alphanumeric data. Among these there are two well-consolidated sectors: CAD (Computer Aided Design) and GIS (Geographical Information Systems). For example, the introduction of CAD technology in the planning process allows the automatisation of the development, updating, reproduction and storage of drawings, which becomes a computerised management of their information content, which is basically metric, or rather, geometric.

On the other hand, GIS have developed from CAD technology. These systems are able to manage and process various types of attribute information linked to the digital representation of space, which in turn is located on the land (*georeferenced*). The geographical representation provided by GIS is, in fact, constructed by referring the co-ordinates of the geometric figures related to the reference system used in official mapping.

This set up allows the introduction of other information levels in the individual graphic drawing (Fig. 1), such as the shape, location and topological relationships existing between the graphical primitive, which add themselves to the metric contents already present in the CAD systems.

Thanks to the data management in tabular form featured in every GIS platform, it is also possible to associate *descriptive attributes* to the graphical primitive. Their contents can vary in number and type (texts or numbers) according to the application to be carried out. They allow the differentiation of the geometric forms that make up the drawing's *real meaning*. For example, an agricultural parcel and a building may be represented in a map by the same graphic symbol, while the introduction of specific descriptive attributes linked to the graphical symbol

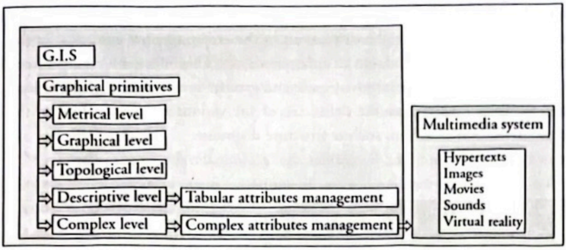



Figure 1 – Management of information levels contained in the graphical primitives of the entire system

(e.g. number of floors for buildings, type of culture for the parcel) allows us to clearly differentiate the two entities.

However, the main GIS feature upon which we will focus on in this study is the ability to manage *complex attributes* (G. Peverieri, 1995). The term *complex attributes* includes all the information that cannot be rendered in tabular form, i.e. images, film sequences, sounds, external applications (which require auxiliary software) or representations featuring different detail degree, which can be contained in the graphical primitive (Fig. 1).

On the basis of this brief description of the potential of GIS, it is easy to perceive how such technology can be used for the integrated management of information concerning the land at every level, and how these systems are useful to all disciplinary fields called upon to study the formal representation of space.

## AN EXAMPLE OF THE TECHNOLOGICAL EVOLUTION OF THE INTEGRATED REGENERATION PROJECT: MULTIMEDIA GEOGRAPHICAL INFORMATION SYSTEM FOR THE MALTESE FORTIFICATIONS REGENERATION PROJECT

The general regeneration project concerns the Fortification System created by the Knights of Malta during the 16th, 17th and 18th centuries. It is characterised by the commitment to create the necessary conditions for carrying out a *reappropriation* of an asset which, though originally of military interest, has turned into cultural heritage. This system is currently in an advanced state of deterioration due mostly to environmental causes (Fig. 2). The variety and number of activities necessary for carrying out the restoration and enhancement of the Fortifications has required a multi-disciplinary approach. For this reason, various research areas have been identified. Each of these areas corresponds to various information levels able to introduce in the planner's cognitive horizon the elements needed for conceiving the actions to be carried out in the environmental context – in the broadest sense of the word – in an appropriate way. This information ranges from the geographical identification of space and geometric description of the objects and facilities involved, to the definition of the various factors involved in the characterisation of action, such as structure diagnosis.

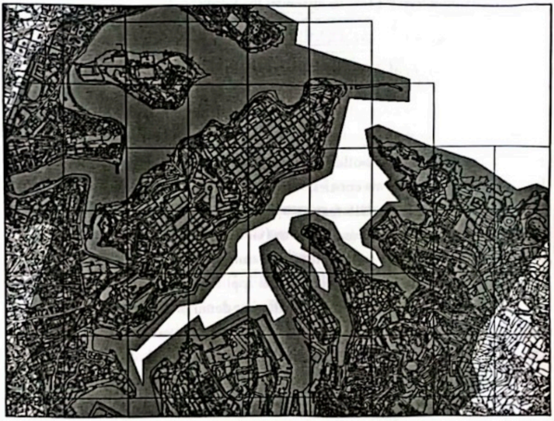


Figure 2 – Area of interest for fortification system restoration and regeneration projects

Based on the homogeneity of information content, it is possible to identify, through a preliminary analysis, various levels:

1. Geographical identification and characterisation of the area affected by the action;
2. Geometric description of the space and objects (buildings, roads, etc.) included in it;
3. Qualitative and quantitative description of the elements of deterioration;
4. Review of the historical and typological evolution of the area and its facilities.

The integrated management of the information contained in these levels can be carried out by using a GIS platform, through which:

- The information content of the first two levels can be expressed by the metric, graphic and descriptive attributes that characterise the graphical primitives used to represent the space and the facilities relevant to the project;

- The third and fourth levels contain information and data which could hardly be represented in tabular form, which leads to the need of complex attributes for which it is necessary to identify specific management methods.

Finally, the four levels contain information which, due to the degree considered, refer to various representations of space ranging from geographical to architectural representation.

It goes without saying that, in order to be introduced in the system, this information must be translated into digital form.

The simultaneous processing of all the information involves the creation of separate modules, yet capable of integration, able to process, store and visualise various types of attributes.

The functional scheme of the system must therefore allow the passage from a geographical representation (which contains information including the actual use of land, the planning tools involved in the study area and road conditions), to a representation of architectural scale objects, to which all the relevant descriptive information should be linked, and which have been previously identified as complex attributes of the graphical representation.

Given this conceptual outline, two conceptual modules have been identified (Fig. 3):

- Territorial representation module;
- Architectural representation module. The integration of the modules allows a complete display spectrum from the geographical scale to the architectural one.

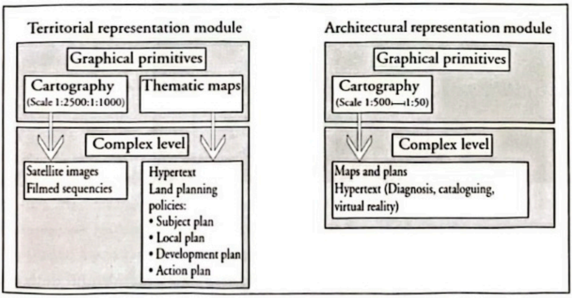



Figure 3 – Functional scheme of the MGIS and contents of the complex level of cartographic primitives

**Territorial representation module (TRM)**

The territorial module is the main element of the system. It is made up of graphical primitives, which can be defined as cartographic data as they are composed essentially of numeric mapping in vector form, including descriptive attributes in tabular form and complex attributes in *hypertext* form.

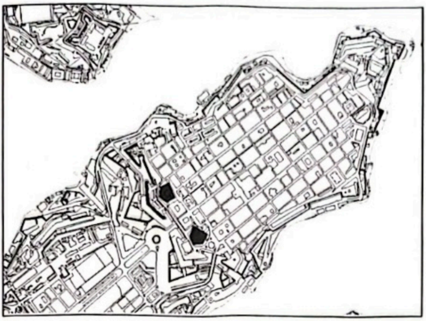
The cartographic maps present in the module derive from aerophotogrammetric surveys carried out in 1988 by the Maltese government featuring a 1:2500 scale, and by the digitalisation of the map included in the Maltese Government urban plan.

Floriana – Fortification system

Valletta – aerial view

The information levels of this module are:

- *graphical level*: the graphical symbols used allow the identification of various objects present over the territory (e.g. distinction between a building and a tree);



Valletta – digital map (scale 1:2500) – fortification areas of interest

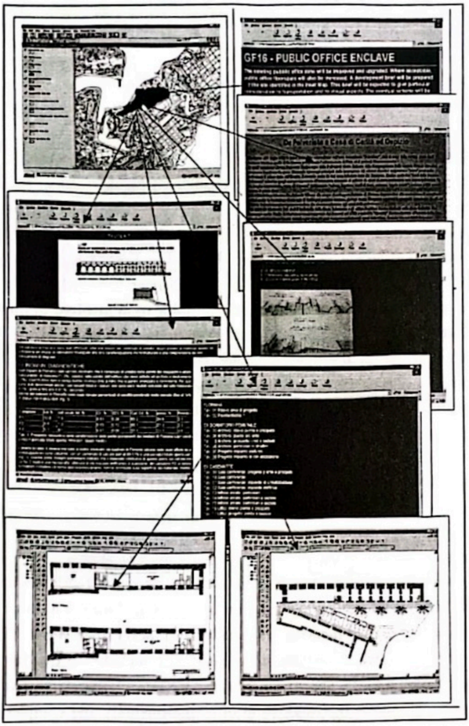
- *metrical level*: allows tracing back to the real (plane) dimensions of objects and their location in the reference plan associated to the cartography (co-ordinates);
- *topological level*: identification of the relationships between objects (what group they belong to, inclusion, confluence);
- *descriptive level:* the graphic elements present in the cartography can be divided into classes based on the attributes they contain in tabular form (e.g. division of buildings according to the building characteristics);
- *complex level:* this contains information in hypertext form, which explains in detail the town and territotorial planning tools involved in the study area, and can be displayed on screen pointing out a graphical element. From this level it is also possible to access information such as photos, filmed sequences, external applications, etc., which can be accessed through the System's multimedia functionalities.

The representation of the space contained by the Module can be completed with the description of the terrain morphology. This information comes from a Digital Elevation Model-DEM (or Digital Terrain Model-DTM), which can be obtained with basis on the topographic height of a specific set of points.

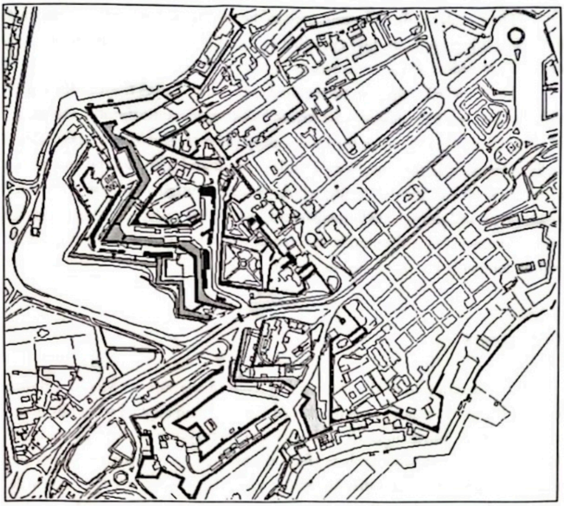
The function of this module is therefore that of containing qualitative and quantitative information regarding space at an urban and/or territorial scale. This information can contribute to the creation of IT tools such as the Local Planes Mosaic. Besides the basic digital cartography, the system created for the Maltese Government features a series of thematic maps such as the Local Planes Mosaic of the Grand Harbour area, which contains all relevant areas included in the first phase of the restoration project. The integrated use of the information contained in the developed tools allows the conduction of both elementary and complex spatial analyses based on the application of models that enable the simulation of various scenarios. The whole of the geographical information contained in this module and its continous updating, made possible through a dynamic configuration of the system, allow the monitoring of sectorial and/or local planning actions, and thus the transformation of the land.

### Architectural representation module (ARM)

The general features of the ARM mainly reflect those of the TRM. The graphic primitives contained in this module derive from photogrammetric surveys on a 1:500 scale and from architectural surveys which reach a scale of detail of 1:500, showing architectural details.




Example of project information management



Floriana – Digital map (scale 1:2500) – fortification areas of interest

The main difference between these modules is, therefore, in the detail scale used for representing the space and objects, and in the contents of some information levels linked to the graphical primitives. Access to this information is an architectural element, after which a change of scale is performed, allowing access to the architectural scale representation of the objects. This step takes place through a change of the graphical primitives used to represent the space, and therefore cannot be assimilated with a simple zoom, which produces a more detailed scale visualisation of the graphical primitive itself.

The graphical, metrical and topological content of the graphical primitive is basically identical to the one previously described for the TRM, in that the information that characterises these levels is implicit, i.e., associated to the geometry of the elements. The descriptive level of the Artefact Representation Module allows, similarly to the preceding module, the subdivision of the graphical elements that compose the graphical primitives into classes (e.g. chronological succession of the actions carried out in a building).

The complex level contains all the tools that knowledge engineering, modelling techniques and computer graphics have made available to computer aided design.

These tools are directly connected to the graphical element that represents the object under study, and it is possible to access it through a main menu that can be displayed on screen in hypertext form.

The knowledge that can be acquired at this level ranges from architectural surveys, supported by photogrammetry, to building diagnosis; from the topological evolution of buildings to the cataloguing of the objects they contain. Especially interesting is the possibility of using urban and architectural modelling techniques, such as Virtual Reality, which, besides its original function of virtual visualisation and surfing, has become increasingly richer with processing and analysis techniques. Once the shift to a metrical environment has taken place, this will undoubtedly become a tool to support design.

## CONCLUSION

The description of the information levels of the various Modules shows how such a system cannot be defined as an expert system applied to architectural design. In fact, "the main characteristic of an expert system is that knowledge is kept separate (in a 'knowledge base') from the mechanism (often called 'inference model') able to draw from that knowledge and infer new knowledge to provide advice and solutions" (A. Radford, G. Stevens, 1987). On the other hand, this objective would be in any case hard to achieve, given the important role played by creativity and by interpretation skills of the symbolic value of the artefact and of its interrelations with the urban environment in the entire planning process. Both characteristics can be traced back to subjective behaviour.

The value of these technologies lies in the communication potential they are able to express. The information contents are, in fact, organised in such a way that "in the place of an overall flow there is a system organised according to a reticular form, instead of a flow of information in input, of a transformation and an output, a simultaneous convergence or consistency of all the parts involved emerges". (Los S., 1987)

In fact, the knowledge of the experts involved in the analytical phase of the project converge in the M.G.I.S. and the architecture of the system allows its constant updating. Furthermore, it can be easily consulted, but not changeable by just anyone, thus guaranteeing the transparency of choices made and, at the same time, allowing greater participation.

Therefore the Multimedia Geographical Information System plays a very precise role in the field of integrated regeneration, that of "placing comprehension before action" (N. Negroponte, 1974), in that it is able to transmit all the necessary knowledge to the end – user (planner) and thus facilitate both technical and political decision-making processes.

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